Deployment of two Cross-Polarized Systems in the ATG Band

Presentation to FCC

Prepared by

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Introduction

- New AirCell-Boeing Proposal:

- Offers two competitive licenses with:
  - broadband service delivery capabilities
  - deck-to-deck coverage
  - simplified “sharing rules”
  - Airfone could keep all existing sites if licensee

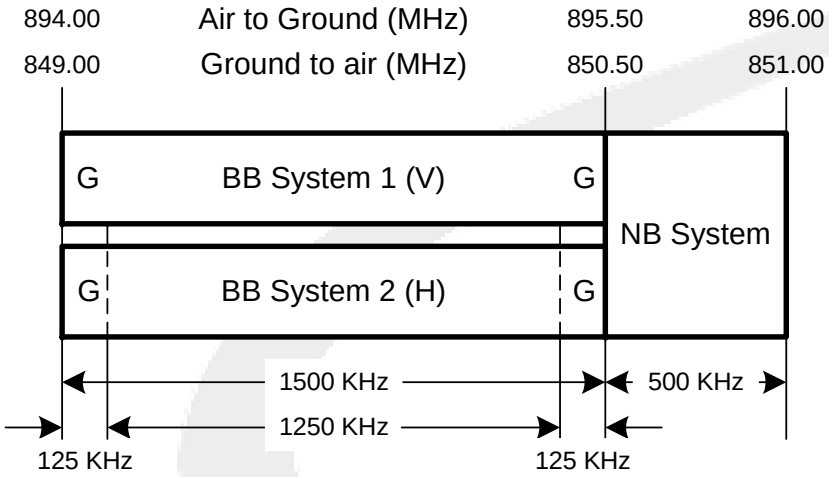
- Analysis
  - Monte Carlo approach using sophisticated Matlab-based system simulation tools
  - no inter-system interference impact - sites can provide full broadband data rates
  - aircraft attitude changes don’t have significant impact

AirCell Two Carrier Scenario

- Utilizes cross-polarization to provide isolation between carriers
  - AirCell tests and operational experience show 12-15 dB (or more) isolation between horizontally polarized and vertically polarized systems
- Utilize frequency offset isolation, once legacy narrowband system is discontinued
  - Provides additional isolation between the two systems (2.2 dB)
- Isolation sufficient to allow two systems to operate with virtually no intersystem impacts
  - both broadband
  - both deck-to-deck

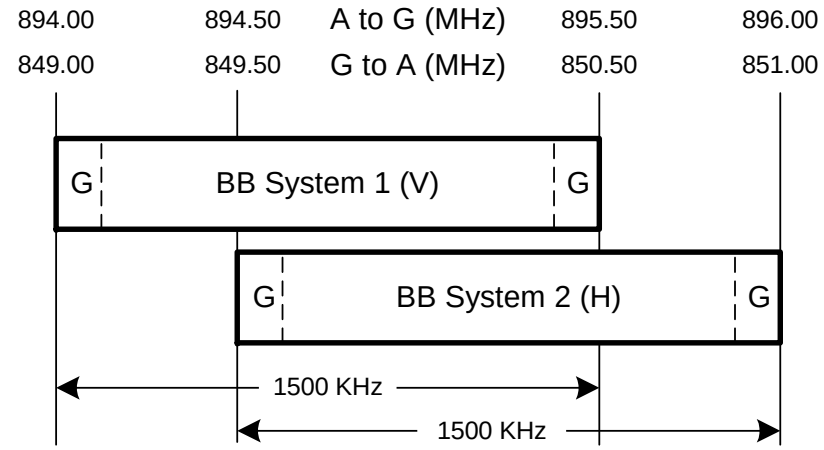
Two Carrier Spectrum Plan

System	Pol	Initial Channels (MHz)		Final Channels (MHz)	
		Ground	Air	Ground	Air
Existing	V	850.50 - 851.00	895.50 - 896.00	-	-
System 1	V	849.00 - 851.50	894.00 - 895.50	849.00 - 851.50	894.00 - 895.50
System 2	H	849.00 - 851.50	894.00 - 895.50	849.50 - 851.00	894.50 - 896.00



G = Guardband BB = Broadband NB = Narrowband

Initial plan, with narrowband system still in operation



G = Guardband BB = Broadband NB = Narrowband

Final plan, after narrowband system operation discontinued

Polarization Isolation

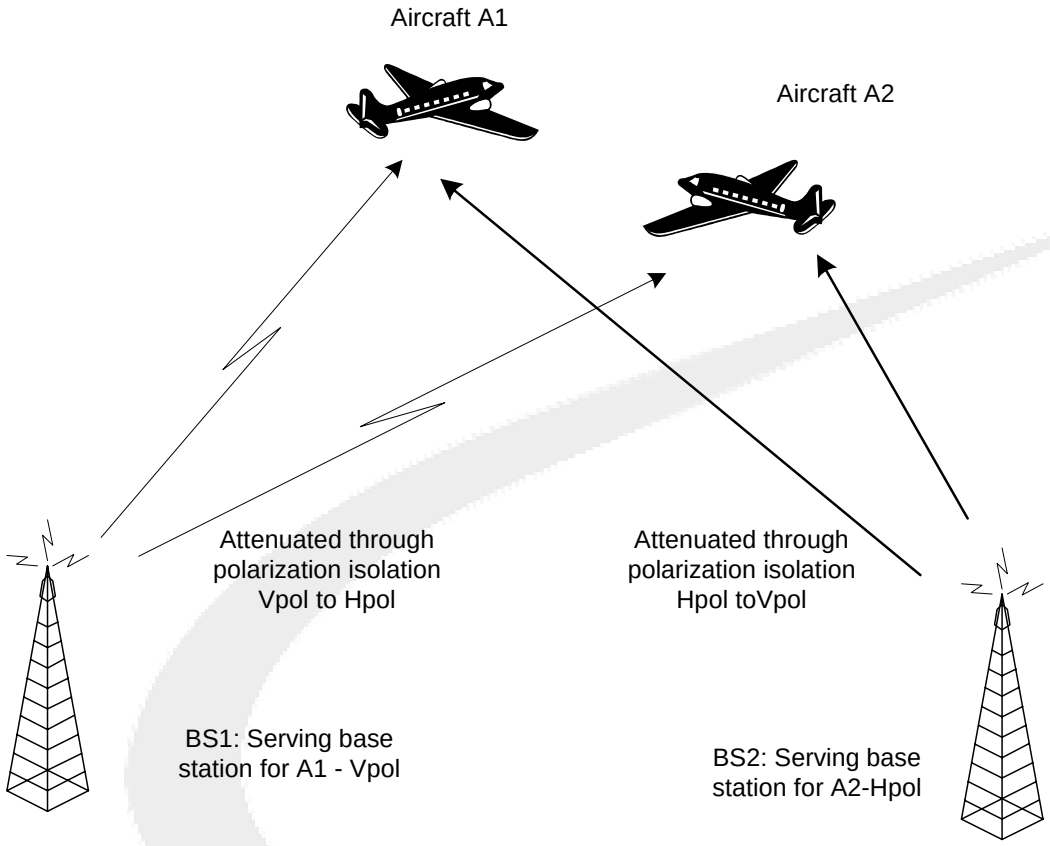


Illustration of forward link interference reduction on cross-polarized systems

- Without isolation technique, interference could occur on both FWD and REV link:
  - FWD to FWD
  - REV to REV
- Interference reduced by polarization isolation
- Effect not the same on FWD link Pilot and Traffic Channels
- REV link interference – “near-far” problem

Near-Far Interference

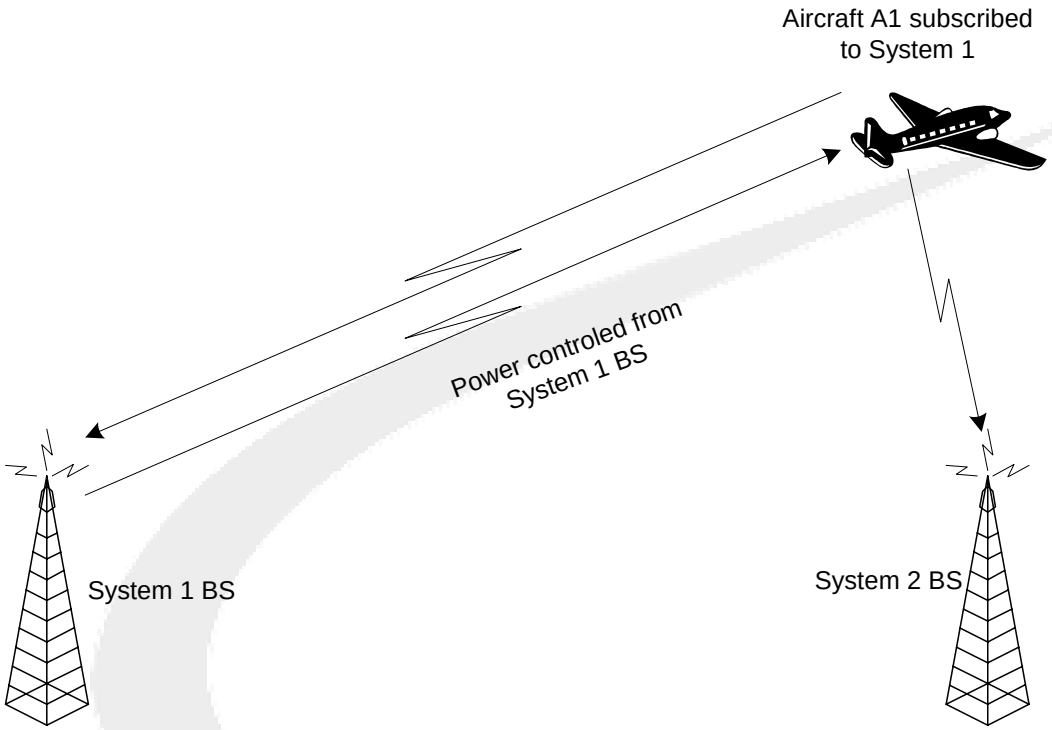


Illustration of forward link interference on cross-polarized systems

- Primarily a potential issue on REV link
- Interference minimized
  - if signal levels from “home” and “foreign” aircraft arrive at similar levels, and
  - XP is sufficient to assure that foreign signals do not have interference impact
- When base stations of two systems are located nearby, power control mechanisms maintain similar signal levels

Simulation Results

- Negligible overall impact on performance of either system
  - Forward link SINR impact <1.2 dB 99% of time for cross-country
  - Forward link SINR impact <2.0 dB 99% of time for airport
  - Reverse link noise rise <0.5 dB 99% at 50% pole point loading (both scenarios)
  - Reverse link noise rise <2.0 dB 99% at 75% pole point loading (both scenarios)

Rule Requirements

- Sites serving same airspace located within 2 miles of each other
  - Licensees can leverage existing reference site list for ATG service to minimize any issues related to agreeing on site locations
  - Airfone can keep all current sites
  - New sites may be added by mutual agreement of licensees
- Carriers must maintain similar coverage from nearby sites
  - Similar antennas and transmit powers
- Carriers have option to build/not build any particular site
  - Transmitters control potential for near-far interference from low altitude aircraft

Observations and Conclusions

- Two systems can operate in ATG band using cross polarization isolation with no impact on either carrier's ability to provide full broadband and deck-to-deck coverage
- Spectrum offset will provide additional "margin of safety" when narrowband service transition is completed
- Eliminates Airfone's concern re Naval radar (no reverse banding)
- No advanced hardware required
  - v-pol and h-pol antennas already in service for ATG
  - terrestrial mobile data equipment readily adaptable
- Aircraft maneuvers will not disrupt polarization isolation
- Minimal, simplified rules

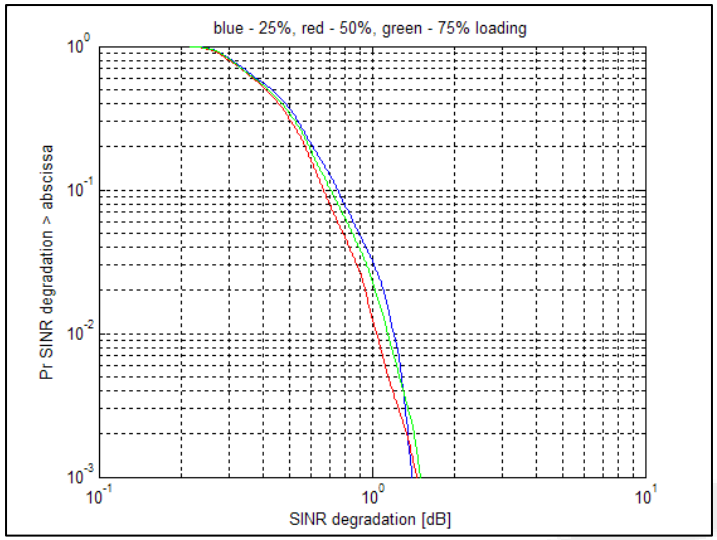
BACKUP SLIDES

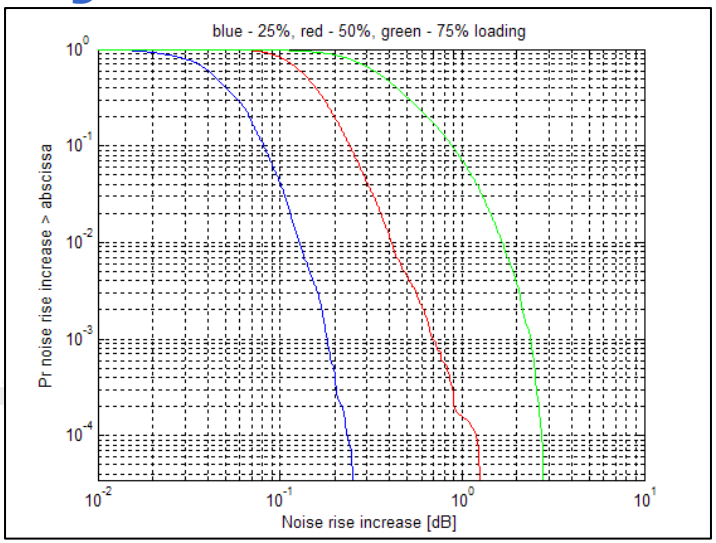
General simulation parameters

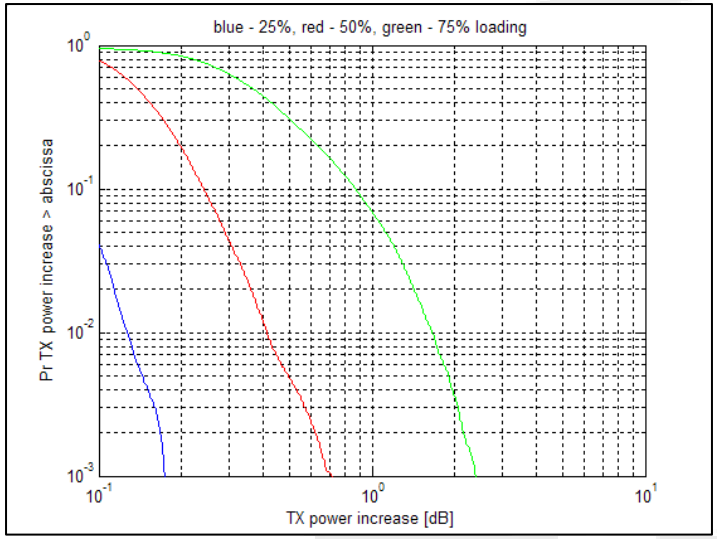
Parameter	Value	Unit	Description
SIM_TIME	7200	Seconds	Duration of the simulation time
TIME_STEP	2	Seconds	Increment of the simulation time
f	870	MHz	Average operating frequency
NumCallsAC	10	-	Average number of voice calls per aircraft of the first
NumCallsAF	10	-	Average number of voice calls per aircraft of the
W	1.2288e6	-	Chip rate for 1xEvDO system
Zmin	0[1], 11000[2]	feet	Minimum aircraft altitude
Zmax	40000	feet	Maximum aircraft altitude
Vmin	380[2], 180[1]	knots	Minimum velocity of the aircraft
Vmax	450[2], 250[1]	knots	Maximum velocity of the aircraft
MinVerSep	1000	feet	Minimum vertical separation between aircraft
MinHorSep	5	nm	Minimum horizontal separation between aircraft
VAF	0.5	-	Average voice activity
FL_IF_Scaling	1	-	Scaling of the interference due to partial overlap
BS.PA_power	20	W	Base station transmit power
BS.NF	4	dB	Base station noise figure
BS.DL_CL	3	dB	Forward link cable losses
BS.UL_CL	3	dB	Reverse link cable losses
MS.PA_power	23	dBm	Mobile station transmit power
MS.NF	8	dB	Noise figure of the mobile
MS.EbNt	4	dB	Required Eb/Nt for the reverse link
R	100[2]	miles	Cell site radius
Pol_Izol	12	dB	Cross-polarization isolation
AG	9[2]/12[1]	dB	Antenna gain

[1] airport scenario; [2] cross-country scenario

Results – cross country scenario

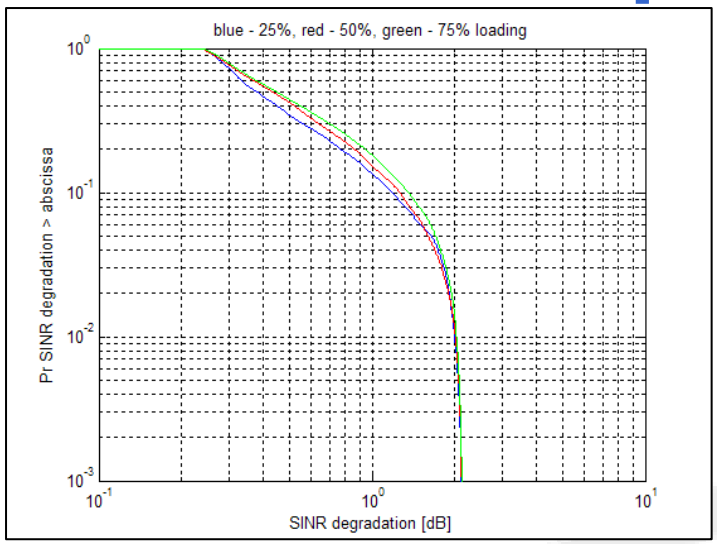


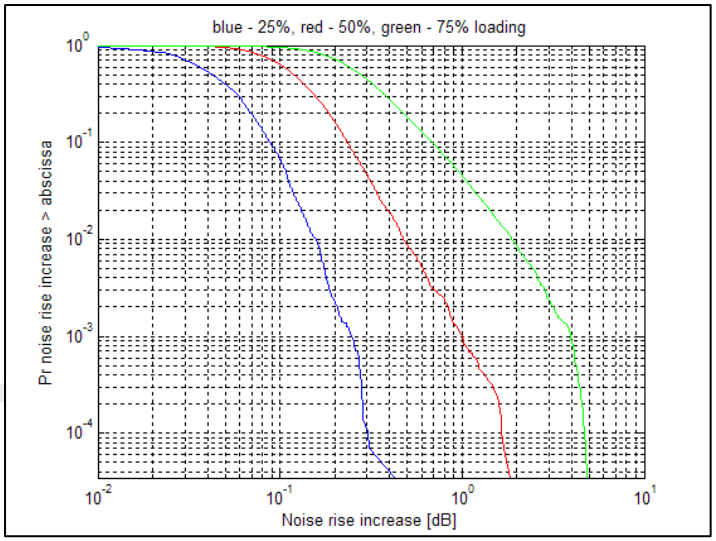


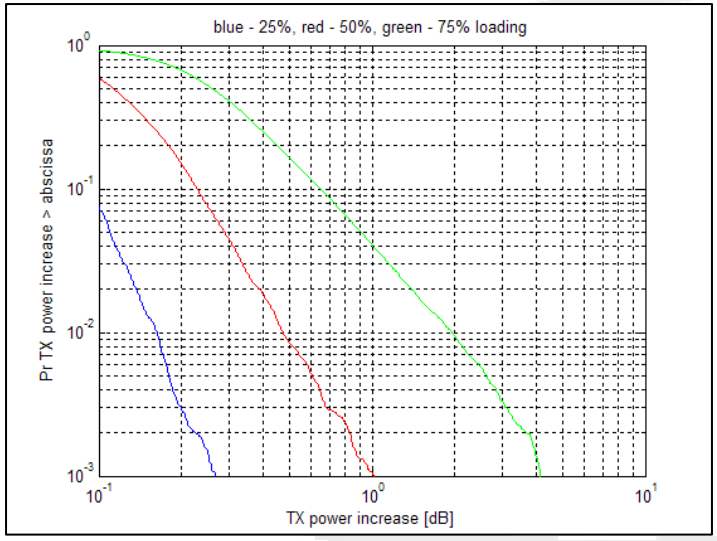


Percent of time	10 %			1%		
Loading	25%	**50%**	75%	25%	**50%**	75%
Degradation in SINR [dB]	0.7	**0.70**	0.7	1.1	**1.2**	1.2
Increase in TX power [dB]	0	**0.25**	0.9	0.13	**0.4**	1.8
Increase in the NR [dB]	0.08	**0.25**	0.9	0.13	**0.4**	1.8

Results – Airport scenario



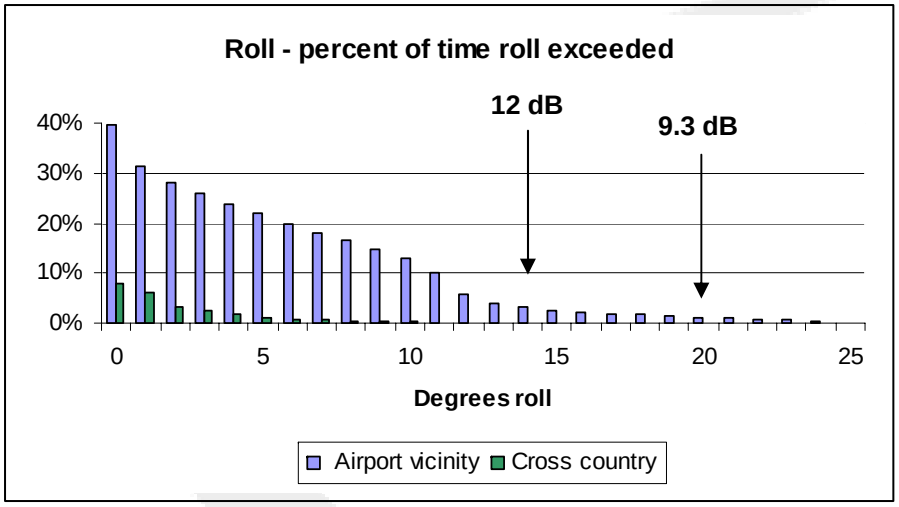


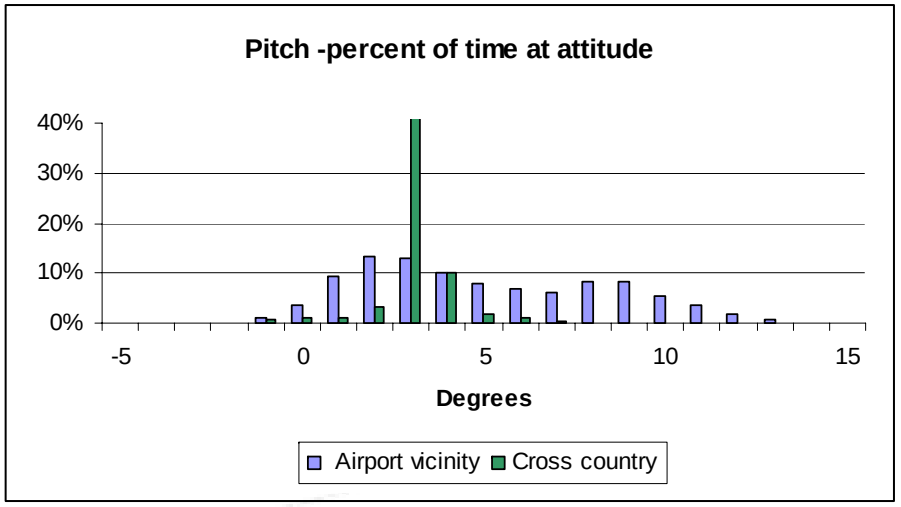


Percent of time	10%			1%		
Loading	25%	**50%**	75%	25%	**50%**	75%
Degradation in SINR [dB]	1.3	**1.3**	1.3	2.0	**2.0**	2.0
Increase in TX power [dB]	0.0	**0.25**	0.65	0.17	**0.5**	2.0
Increase in the NR [dB]	0.09	**0.25**	0.65	0.17	**0.5**	2.0

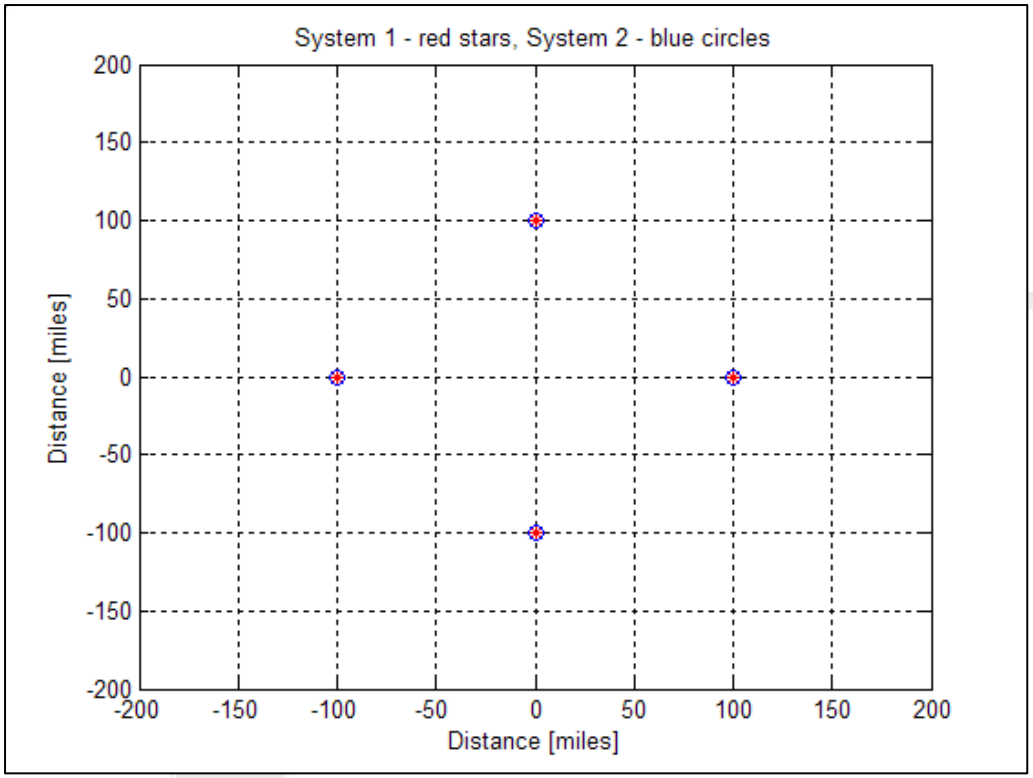
Impact of aircraft maneuvers

- **Analysis by Boeing for sample of aircraft over variety of airports**
  - Evaluated pitch and roll for cross country routes and for vicinity of airports
    - greatest orientation change will be from roll in vicinity of airports - roll is less than 14° 97% of the time, less than 20° 98.8% of the time.
  - Polarization isolation of 12 dB or more is achieved for more than 99% of time





Cross Country XP simulator



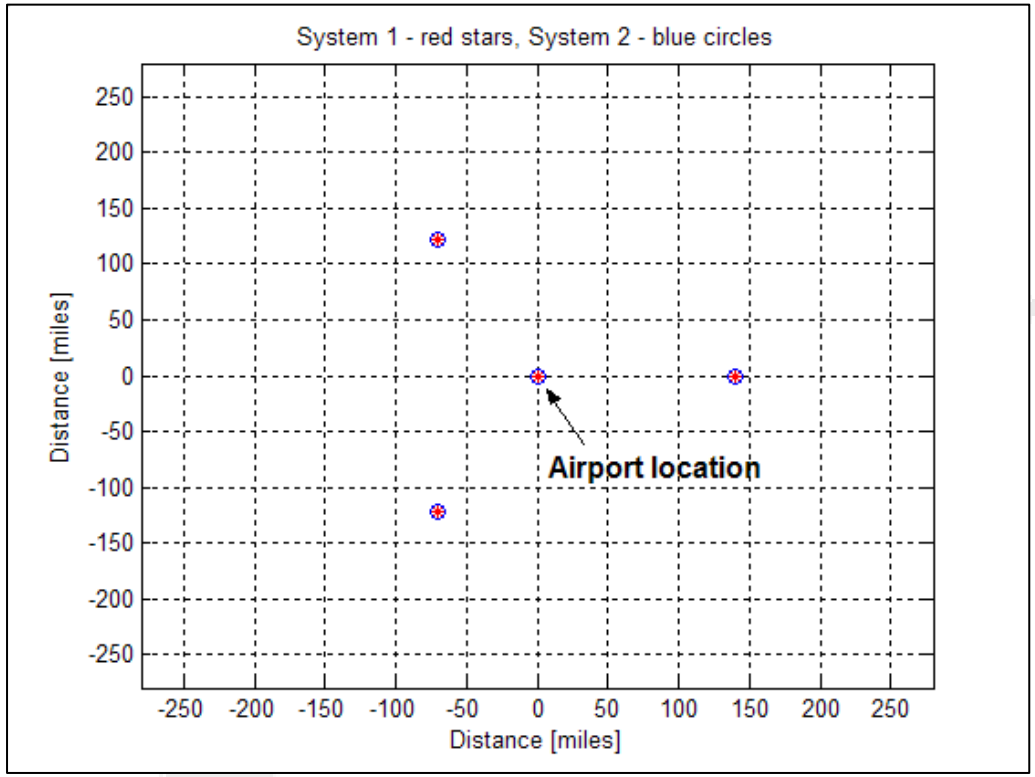
Topology of the inter-system test bed for cross-country scenario

Simulation parameters

- Omni-directional sites
- One network H-pol, other network V-pol
- Antenna patterns with envelope of current aircell antenna
- Altitudes 18,000 – 40,000 feet
- Average of 10 voice calls per plane
- Three different loading scenarios

Loading [%]	Number of aircraft
25	4
50	8
75	12

Airport Scenario XP simulator



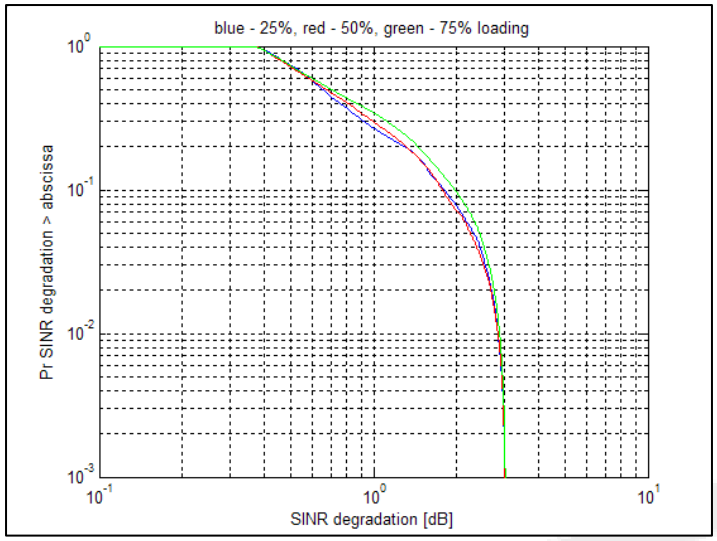
Topology of the inter-system test bed for airport scenario

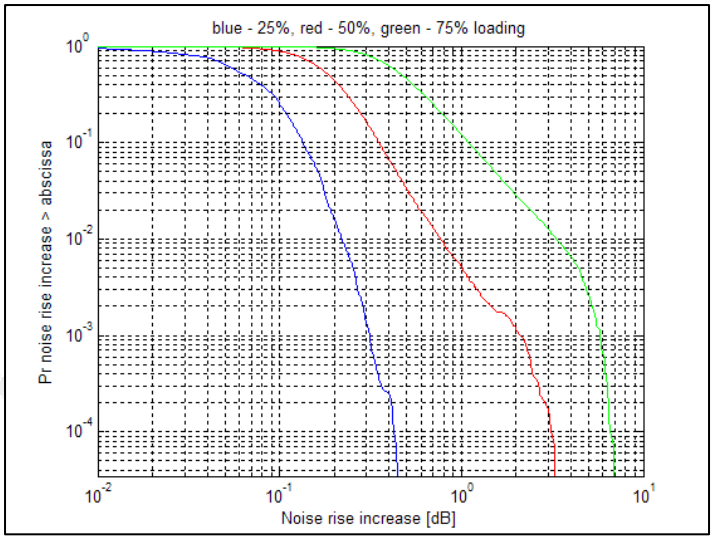
Simulation parameters

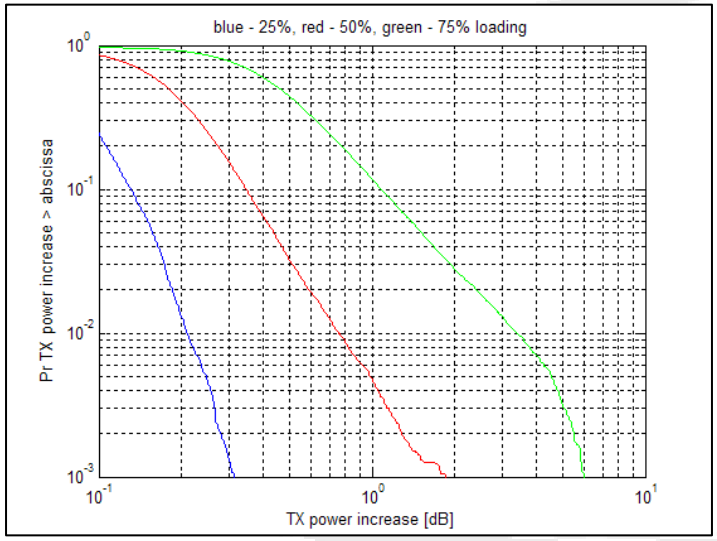
- Omni sites
- One network H-pol, other network V-pol
- Antenna patterns with envelope of current aircell antenna
- Altitudes 0 – 40,000 feet, constrained by approach/departure routes
- 10 voice calls per plane
- Three different loading scenarios:

Loading [%]	Number of aircraft
25	4
50	8
75	12

Results – Airport scenario - 10 dB XPD

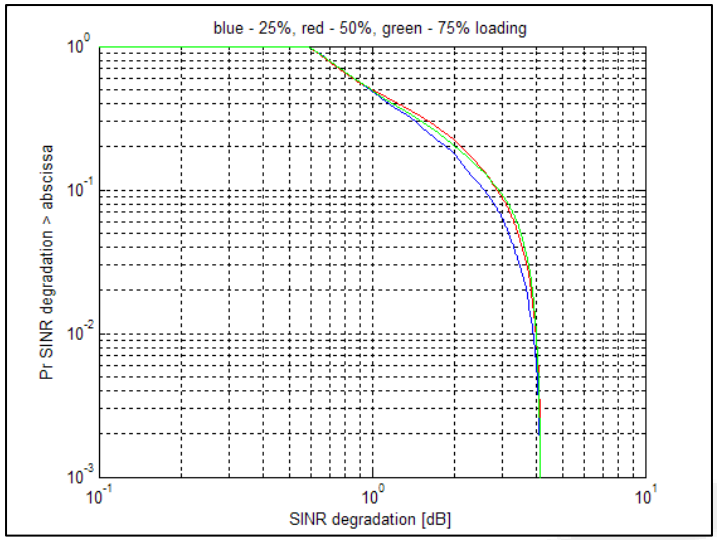


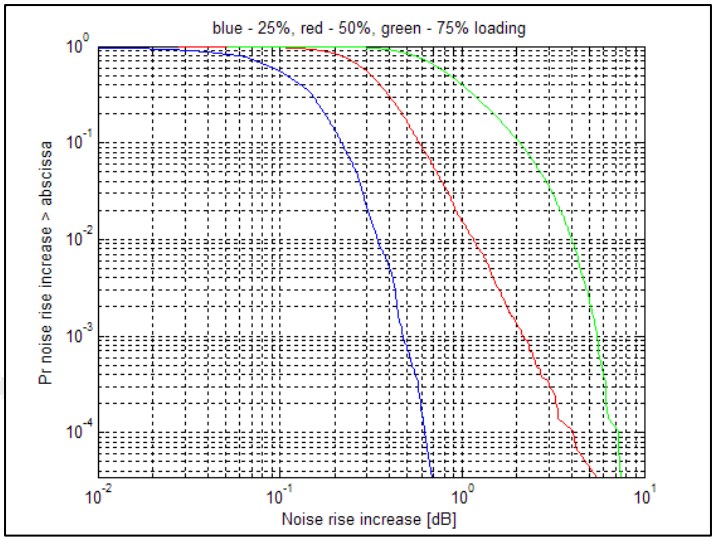


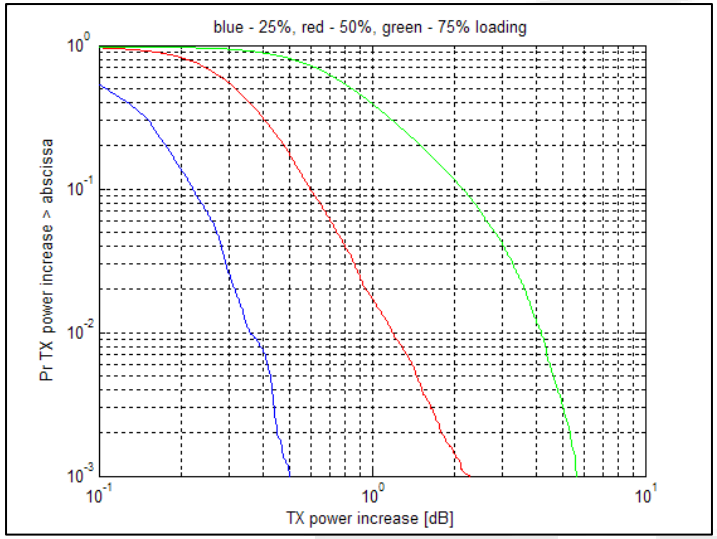


Percent of time	10%			1%		
Loading	25%	**50%**	75%	25%	**50%**	75%
Degradation in SINR [dB]	1.8	**1.8**	2.0	2.9	**2.9**	2.9
Increase in TX power [dB]	0.14	**0.35**	1.1	0.21	**0.75**	3.5
Increase in the NR [dB]	0.14	**0.25**	1.1	0.22	**0.75**	3.2

Results – Airport scenario - 8 dB XPD







Percent of time	10%			1%		
Loading	25%	**50%**	75%	25%	**50%**	75%
Degradation in SINR [dB]	1.9	**2.0**	2.1	3.6	**3.7**	3.8
Increase in TX power [dB]	0.22	**0.66**	2.1	0.36	**1.3**	4.2
Increase in the NR [dB]	0.22	**0.57**	2.0	0.35	**1.2**	4.0